

WHAT IS CLAIMED IS:

1. A method of removing hydrogen sulfide from an emissions stream, comprising:
  - directing the emissions stream into a hydrogen sulfide converter having a metal oxide catalyst;
  - adsorbing the hydrogen sulfide in the emissions stream to the metal oxide catalyst in the hydrogen sulfide converter;
  - reacting the hydrogen sulfide with at least one of an oxidant and a reductant in the hydrogen sulfide converter to chemically transform the hydrogen sulfide; and
- 10 adjusting an air-fuel ratio of the emissions stream based on exhaust temperature of an emission control device, where said adjustment varies a duration of at least one of lean and rich operation to perform said adsorbing and reacting even as exhaust temperature varies.
- 15 2. The method of claim 1, wherein the metal oxide catalyst includes nickel oxide.
3. The method of claim 2, wherein the hydrogen sulfide is reacted with the reductant to form nickel sulfide.
- 20 4. The method of claim 3, wherein the reductant is hydrogen gas.

5. The method of claim 3, further comprising reacting the nickel sulfide with an oxidant to form nickel sulfate.

6. The method of claim 5, wherein the oxidant includes at least one substance  
5 selected from the group consisting of oxygen and sulfur dioxide.

7. The method of claim 5, wherein the oxidant is produced by a combustion engine running a lean air/fuel mixture.

10 8. The method of claim 5, wherein the nickel sulfide is reacted with the oxidant at a temperature of between approximately 625 and 675 degrees Celsius.

9. The method of claim 5, wherein the nickel sulfide is reacted with the oxidant at a temperature of between approximately 575 and 625 degrees Celsius.

15 10. The method of claim 5, further comprising reacting the nickel sulfate with a reductant to produce sulfur dioxide and to regenerate the nickel oxide.

11. The method of claim 10, wherein the reductant is hydrogen gas.

20 12. The method of claim 3, further comprising reacting the nickel sulfide with oxygen to directly form nickel oxide and sulfur dioxide.

13. The method of claim 3, wherein the nickel sulfide is reacted with the oxidant at a temperature of between 350 and 400 degrees Celsius.

14. The method of claim 1, wherein the reductant is hydrogen gas.

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15. The method of claim 14, wherein the hydrogen gas is produced by a combustion engine running a rich air/fuel mixture.

16. A method of desulfating a catalytic converter, comprising:  
10 transforming sulfur in the catalytic converter to hydrogen sulfide;  
transporting the hydrogen sulfide out of the catalytic converter;  
adsorbing the hydrogen sulfide to a nickel oxide catalyst; and  
flowing varying amounts of a reductant and an oxidant over the nickel  
oxide catalyst to chemically transform the hydrogen sulfide into at least one other  
15 gas-phase sulfur compound, wherein said varying amounts are selected based on exhaust  
temperature of the catalytic converter, where said selection varies a duration of exposure  
of said reductant to perform said transforming even as exhaust temperature varies.

17. The method of claim 16, wherein the at least one other gas-phase sulfur  
20 compound is sulfur dioxide.

18. The method of claim 17, wherein the hydrogen sulfide is converted to sulfur dioxide via an intermediate nickel sulfide compound.

19. The method of claim 18, wherein flowing varying amounts of a reductant and  
5 an oxidant over the nickel oxide catalyst includes first flowing hydrogen over the catalyst to reduce the hydrogen sulfide to nickel sulfide, then flowing at least one of oxygen and sulfur dioxide over the catalyst to convert the nickel sulfide to nickel sulfate, and then flowing hydrogen over the catalyst to convert the nickel sulfate to nickel oxide and sulfur dioxide.

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20. The method of claim 17, wherein flowing varying amounts of a reductant and an oxidant over the nickel oxide catalyst includes first flowing hydrogen over the catalyst to reduce the hydrogen sulfide to nickel sulfide, then flowing oxygen over the catalyst to directly convert the nickel sulfide to sulfur dioxide.

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21. A method of desulfating a catalytic converter, comprising:  
adjusting an exhaust air-fuel ratio entering said catalytic converter between  
rich and lean operation, where durations of said rich and lean operation are adjusted  
based on catalyst temperature to:

5           form hydrogen sulfide from sulfur in the catalytic converter;  
              transport the hydrogen sulfide out of the catalytic converter and into a  
              nickel oxide catalyst downstream of the catalytic converter;  
              form nickel sulfide from the hydrogen sulfide in the nickel oxide catalyst;  
and  
10          form sulfur dioxide from the nickel sulfide in the nickel oxide catalyst.

22. The method of claim 21, wherein forming nickel sulfide from the hydrogen  
sulfide includes reacting the hydrogen sulfide with hydrogen gas on the nickel oxide  
catalyst.

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23. The method of claim 21, wherein the hydrogen sulfide is reacted with  
hydrogen gas at a temperature of between approximately 625 and 675 degrees Celsius.

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24. The method of claim 21, wherein the hydrogen gas is produced by a  
combustion engine running a rich air/fuel mixture.

25. The method of claim 21, wherein forming sulfur dioxide from the nickel sulfide includes forming nickel sulfate from the nickel sulfide, and then forming sulfur dioxide from the nickel sulfate.

5        26. The method of claim 25, wherein the nickel sulfate is formed by reacting the nickel sulfide with oxygen and sulfur dioxide, and wherein the sulfur dioxide is formed by reacting the nickel sulfate with hydrogen.

10      27. The method of claim 26, wherein the hydrogen is produced by a combustion engine running a rich air/fuel mixture.

15      28. The method of claim 26, wherein the nickel sulfide is reacted with oxygen and sulfur dioxide at a temperature of approximately 600 degrees Celsius, and wherein the nickel sulfate is reacted with hydrogen at a temperature of approximately 650 degrees Celsius.

20      29. The method of claim 21, wherein forming sulfur dioxide from the nickel sulfate includes reacting the nickel sulfide with oxygen to form sulfur dioxide directly.

20      30. The method of claim 29, wherein the nickel sulfide is reacted with the oxygen at a temperature of between 350 and 400 degrees Celsius.

31. In a mechanical apparatus having a combustion engine, a method of desulfating a catalytic converter, the method comprising:

forming hydrogen sulfide from sulfur in the catalytic converter;

transporting the hydrogen sulfide out of the catalytic converter and into a nickel

5      oxide catalyst downstream of the catalytic converter;

providing a rich air/fuel ratio to the combustion engine for a first interval to increase an amount of a reductant in an exhaust stream from the engine; and

providing a lean air/fuel ratio to the combustion engine for a second interval to increase an amount of an oxidant in the exhaust stream, wherein durations of said rich

10     and lean air/fuel ratios are adjusted based on exhaust temperature of the converter.

32. The method of claim 31, wherein the reductant is hydrogen and reacts with the hydrogen sulfide on the nickel oxide catalyst to form nickel sulfide.

15     33. The method of claim 32, wherein the oxidant is oxygen and reacts with the nickel sulfide to form at least one of nickel sulfate and sulfur dioxide.

34. The method of claim 33, wherein the oxidant reacts with the nickel sulfide to form nickel sulfate, further comprising reacting the nickel sulfate with hydrogen to form

20     sulfur dioxide.

35. The method of claim 34, wherein the hydrogen is formed by providing a rich air/fuel ratio to the combustion engine.

36. The method of claim 31, further comprising providing a rich air/fuel ratio to the combustion engine for a third interval.

5       37. The method of claim 31, wherein at least one of the first interval and second interval is defined by a fixed period of time.

10      38. The method of claim 31, wherein at least one of the first interval and second interval is defined by a number of engine cycles.

15      39. The method of claim 31, wherein the first interval is defined by a saturation point of hydrogen sulfide on the nickel oxide catalyst.

40. The method of claim 31, wherein the second interval is defined by a saturation point of an oxidant on a nickel sulfide intermediate.

41. A method of removing hydrogen sulfide from an emissions stream, comprising:

directing the emissions stream into a hydrogen sulfide converter having a metal oxide catalyst;

5 adsorbing the hydrogen sulfide in the emissions stream to the metal oxide catalyst in the hydrogen sulfide converter;

reacting the hydrogen sulfide with a reductant in the hydrogen sulfide converter to chemically transform the hydrogen sulfide to a metal sulfide; and

reacting the metal sulfide with an oxidant to form a gaseous sulfur oxide and to  
10 regenerate the metal oxide.

42. The method of claim 41, wherein the metal oxide is nickel oxide.

43. The method of claim 41, wherein the hydrogen sulfide is reacted with the  
15 reductant at a temperature of approximately 650 degrees Celsius.

44. The method of claim 41, wherein the metal sulfide is reacted with the oxidant  
at a temperature of between approximately 350 and 400 degrees Celsius.

20 45. The method of claim 41, wherein the reductant is produced by supplying a  
rich air/fuel mixture to an engine that produces the emissions stream.

46. The method of claim 41, wherein the oxidant is produced by supplying a lean air/fuel mixture to an engine that produces the emissions stream.